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(54) Title: AMIDE AND CARBAMATE DERIVATIVES OF ALKYL SUBSTITUTED N-[4-(4-AMINO-1H-IMIDAZO[4,5-C]QUINOLIN-1-YL)BUTYL]METHANESULFONAMIDES AND METHODS

(57) Abstract: Amide and carbamate derivatives of N-[4-(4-amino-1H-imidazo[4,5-c]quinolin-1-yl)butyl]methanesulfonamides with an ethyl, methyl, or n-propyl substituent at the 2-position, pharmaceutical compositions containing these compounds, methods of making the compounds, and methods of use of these compounds in modulating the immune system, for inducing cytokine biosynthesis in animals and in the treatment of diseases including viral and neoplastic diseases, are disclosed.

AMIDE AND CARBAMATE DERIVATIVES OF ALKYL SUBSTITUTED *N*-[4-(4-AMINO-1*H*-IMIDAZO[4,5-*c*]QUINOLIN-1-YL)BUTYL]METHANESULFONAMIDES AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention claims priority to U.S. Provisional Application Serial No. 60/715,949, filed September 9, 2005, which is incorporated herein by reference.

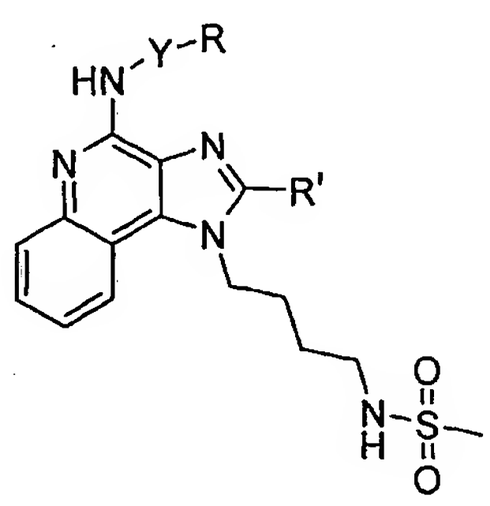
BACKGROUND

Certain substituted 1*H*-imidazo[4,5-*c*] pyridin-4-amine, quinolin-4-amine, tetrahydroquinolin-4-amine, naphthyridin-4-amine, and tetrahydronaphthyridin-4-amine compounds as well as certain analogous thiazolo and oxazolo compounds have been found to be useful as immune response modifiers (IRMs), rendering them useful in the treatment of a variety of disorders.

There continues to be interest in and a need for compounds, the administration of which can give rise to modulation of the immune response, through induction of cytokine biosynthesis or other mechanisms.

SUMMARY OF THE INVENTION

It has now been found that certain amide and carbamate derivatives of 2-alkyl *N*-[4-(4-amino-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamides give rise to induction of cytokine biosynthesis. The present invention provides such compounds, which are of the following Formula I:



I

wherein R, R', and Y are as defined below; and pharmaceutically acceptable salts thereof.

The compounds or salts of Formulas I are useful due to their ability to give rise to modulation of cytokine biosynthesis (e.g., induce the biosynthesis or production of one or more cytokines) and otherwise bring about modulation of the immune response when administered to animals. This makes the compounds useful in the treatment of a variety of conditions, such as viral diseases and neoplastic diseases, that are responsive to such changes in the immune response.

The present invention also provides pharmaceutical compositions containing the compounds of Formula I and methods of inducing cytokine biosynthesis in animal cells, treating a viral disease in an animal, and/or treating a neoplastic disease in an animal by administering to the animal one or more compounds of the Formula I, and/or pharmaceutically acceptable salts thereof, or by administering to the animal a pharmaceutical composition containing one or more compounds of the Formula I, and/or pharmaceutically acceptable salts thereof.

In another aspect, the invention provides methods of synthesizing the compounds of Formula I.

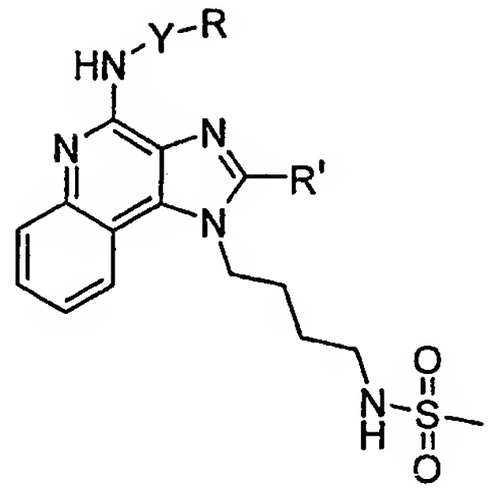
As used herein, "a," "an," "the," "at least one," and "one or more" are used interchangeably.

The terms "comprising" and variations thereof do not have a limiting meaning where these terms appear in the description and claims.

The above summary of the present invention is not intended to describe each disclosed embodiment or every implementation of the present invention. The description that follows more particularly exemplifies illustrative embodiments. Guidance is also provided herein through lists of examples, which can be used in various combinations. In each instance, the recited list serves only as a representative group and should not be interpreted as an exclusive list.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS OF THE INVENTION

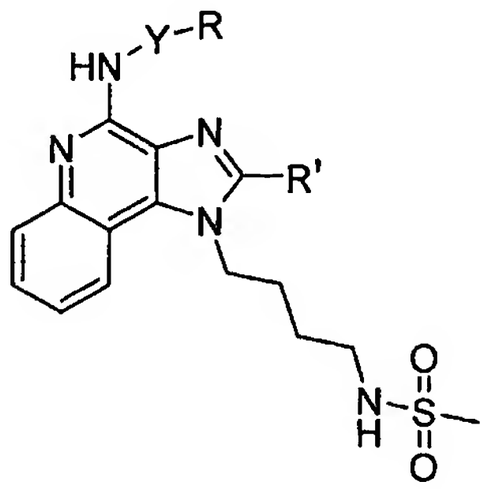
The present invention provides compounds of the following Formula I:



I

wherein R, R', and Y are as defined below; and pharmaceutically acceptable salts thereof.

In one embodiment, the present invention provides a compound of the following Formula I:



I

wherein:

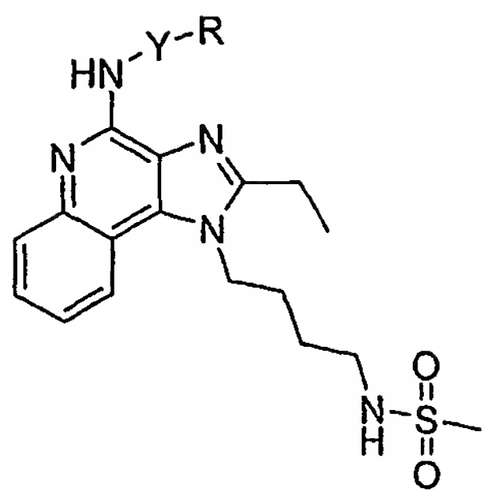
Y is selected from the group consisting of -C(O)- and -C(O)-O-;

R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl; wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom; and

R' is selected from the group consisting of methyl, ethyl, and *n*-propyl;

or a pharmaceutically acceptable salt thereof.

In one embodiment, the present invention provides a compound of the following Formula II:



II

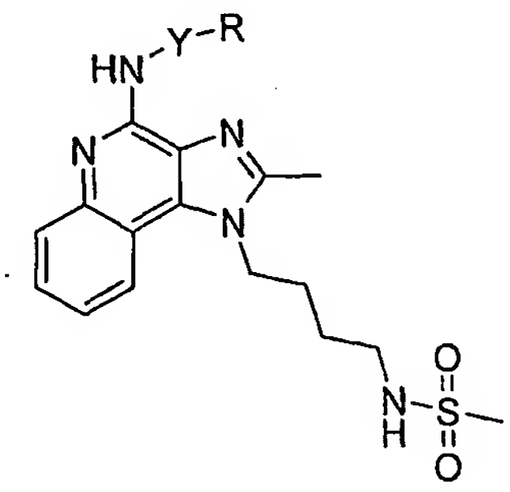
wherein:

Y is selected from the group consisting of -C(O)- and -C(O)-O-; and

R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl; wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom;

or a pharmaceutically acceptable salt thereof.

In another embodiment, the present invention provides a compound of the following Formula III:



III

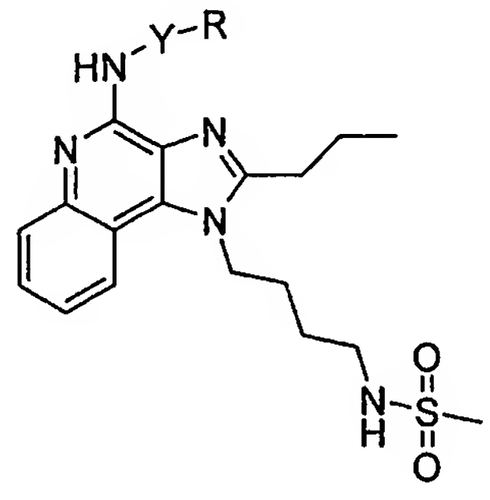
wherein:

Y is selected from the group consisting of -C(O)- and -C(O)-O-; and

R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl; wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom;

or a pharmaceutically acceptable salt thereof.

In another embodiment, the present invention provides a compound of the following Formula IV:



IV

wherein:

Y is selected from the group consisting of -C(O)- and -C(O)-O-; and

R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl; wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom;
or a pharmaceutically acceptable salt thereof.

For any of the compounds presented herein, each one of the following variables (e.g., R, R', Y, and so on) in any of its embodiments can be combined with any one or more of the other variables in any of their embodiments and associated with any one of the formulas described herein, as would be understood by one of skill in the art. Each of the resulting combinations of variables is an embodiment of the present invention.

For certain embodiments, e.g., of any one of Formulas I through IV, Y is selected from the group consisting of -C(O)- and -C(O)-O-.

For certain embodiments, e.g., of any one of Formulas I through IV, Y is -C(O)-.

For certain embodiments, e.g., of any one of Formulas I through IV, Y is -C(O)-O-.

For certain embodiments, including any one of the above embodiments of Formulas I through IV, R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl;

wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom.

For certain embodiments, including any one of the above embodiments of Formulas I through IV, R is alkyl, aryl, or arylalkylenyl. For certain of these embodiments, R is $C_{1\text{-}10}$ alkyl. For certain of these embodiments, R is $C_{1\text{-}5}$ alkyl. For certain of these embodiments, R is selected from the group consisting of methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, and *tert*-butyl.

For certain embodiments, including any one of the above embodiments of Formulas I through IV, where not excluded, R is aryl. For certain of these embodiments, R is phenyl.

For certain embodiments, including any one of the above embodiments of Formulas I through IV, where not excluded, R is arylalkylenyl. For certain of these embodiments, R is benzyl.

For certain embodiments, including any one of the above embodiments of Formula I, R' is selected from the group consisting of methyl, ethyl, and *n*-propyl.

For certain embodiments, including any one of the above embodiments of Formula I, R' is ethyl.

For certain embodiments, including any one of the above embodiments of Formula I, where not excluded, R' is methyl.

For certain embodiments, including any one of the above embodiments of Formula I, where not excluded, R' is *n*-propyl.

For certain embodiments, the present invention provides a pharmaceutical composition comprising a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV, and a pharmaceutically acceptable carrier.

For certain embodiments, the present invention provides a method of inducing cytokine biosynthesis in an animal comprising administering an effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV, or a pharmaceutical composition comprising a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV to the animal.

For certain embodiments, the present invention provides a method of treating a viral disease in an animal comprising administering a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV, or a pharmaceutical composition comprising a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV to the animal.

For certain embodiments, the present invention provides a method of treating a neoplastic disease in an animal comprising administering a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV, or a pharmaceutical composition comprising a therapeutically effective amount of a compound or salt of any one of the above embodiments of Formulas I, II, III, and IV to the animal.

As used herein, the terms "alkyl" and the prefix "alk-" are inclusive of both straight chain and branched chain groups and of cyclic groups, e.g., cycloalkyl and cycloalkenyl. Unless otherwise specified, these groups contain from 1 to 20 carbon atoms, with alkenyl groups containing from 2 to 20 carbon atoms, and alkynyl groups containing from 2 to 20 carbon atoms. In some embodiments, these groups have a total of up to 10 carbon atoms, up to 8 carbon atoms, up to 6 carbon atoms, or up to 4 carbon atoms. Cyclic groups can be monocyclic or polycyclic and preferably have from 3 to 10 ring carbon atoms. Exemplary cyclic groups include cyclopropyl, cyclopropylmethyl, cyclobutyl, cyclobutylmethyl, cyclopentyl, cyclopentylmethyl, cyclohexyl, cyclohexylmethyl, adamantyl, and substituted and unsubstituted bornyl, norbornyl, and norbornenyl.

Unless otherwise specified, "alkylene," is the divalent forms of the "alkyl" groups defined above. The term "alkylenyl" is used when "alkylene"is substituted. For example, an arylalkylenyl group comprises an "alkylene" moiety to which an aryl group is attached.

The term "aryl" as used herein includes carbocyclic aromatic rings or ring systems. Examples of aryl groups include phenyl, naphthyl, biphenyl, fluorenyl and indenyl.

Unless otherwise indicated, the term "heteroatom" refers to the atoms O, S, or N.

The term "heteroaryl" includes aromatic rings or ring systems that contain at least one ring heteroatom (e.g., O, S, N). In some embodiments, the term "heteroaryl" includes a ring or ring system that contains 2 to 12 carbon atoms, 1 to 3 rings, 1 to 4 heteroatoms, and O, S, and/or N as the heteroatoms. Suitable heteroaryl groups include furyl, thienyl, pyridyl, quinolinyl, isoquinolinyl, indolyl, isoindolyl, triazolyl, pyrrolyl, tetrazolyl,

imidazolyl, pyrazolyl, oxazolyl, thiazolyl, benzofuranyl, benzothiophenyl, carbazolyl, benzoxazolyl, pyrimidinyl, benzimidazolyl, quinoxalinyl, benzothiazolyl, naphthyridinyl, isoxazolyl, isothiazolyl, purinyl, quinazolinyl, pyrazinyl, 1-oxidopyridyl, pyridazinyl, triazinyl, tetrazinyl, oxadiazolyl, thiadiazolyl, and so on.

The term "heterocyclyl" includes non-aromatic rings or ring systems that contain at least one ring heteroatom (e.g., O, S, N) and includes all of the fully saturated and partially unsaturated derivatives of the above mentioned heteroaryl groups. In some embodiments, the term "heterocyclyl" includes a ring or ring system that contains 2 to 12 carbon atoms, 1 to 3 rings, 1 to 4 heteroatoms, and O, S, and N as the heteroatoms. Exemplary heterocyclyl groups include pyrrolidinyl, tetrahydrofuranyl, morpholinyl, thiomorpholinyl, 1,1-dioxothiomorpholinyl, piperidinyl, piperazinyl, thiazolidinyl, imidazolidinyl, isothiazolidinyl, tetrahydropyranyl, quinuclidinyl, homopiperidinyl (azepanyl), 1,4-oxazepanyl, homopiperazinyl (diazepanyl), 1,3-dioxolanyl, aziridinyl, azetidinyl, dihydroisoquinolin-(1*H*)-yl, octahydroisoquinolin-(1*H*)-yl, dihydroquinolin-(2*H*)-yl, octahydroquinolin-(2*H*)-yl, dihydro-1*H*-imidazolyl, 3-azabicyclo[3.2.2]non-3-yl, and the like.

The term "heterocyclyl" includes bicylic and tricyclic heterocyclic ring systems. Such ring systems include fused and/or bridged rings and spiro rings. Fused rings can include, in addition to a saturated or partially saturated ring, an aromatic ring, for example, a benzene ring. Spiro rings include two rings joined by one spiro atom and three rings joined by two spiro atoms.

When "heterocyclyl" contains a nitrogen atom, the point of attachment of the heterocyclyl group may be the nitrogen atom unless otherwise specified.

The invention is inclusive of the compounds described herein (including intermediates) in any of their pharmaceutically acceptable forms, including isomers (e.g., diastereomers and enantiomers), salts, solvates, polymorphs, and the like. In particular, if a compound is optically active, the invention specifically includes each of the compound's enantiomers as well as racemic and scalemic mixtures of the enantiomers. It should be understood that the term "compound" includes any or all of such forms, whether explicitly stated or not (although at times, "salts" are explicitly stated).

Preparation of the Compounds

Compounds of the invention may be synthesized by synthetic routes that include processes analogous to those well known in the chemical arts, particularly in light of the description contained herein. The reagents are generally available from commercial sources such as Aldrich Chemicals (Milwaukee, Wisconsin, USA) or are readily prepared using methods well known to those skilled in the art (e.g., prepared by methods generally described in Louis F. Fieser and Mary Fieser, *Reagents for Organic Synthesis*, v. 1-19, Wiley, New York, (1967-1999 ed.); Alan R. Katritsky, Otto Meth-Cohn, Charles W. Rees, *Comprehensive Organic Functional Group Transformations*, v 1-6, Pergamon Press, Oxford, England, (1995); Barry M. Trost and Ian Fleming, *Comprehensive Organic Synthesis*, v. 1-8, Pergamon Press, Oxford, England, (1991); or *Beilsteins Handbuch der organischen Chemie*, 4, Aufl. Ed. Springer-Verlag, Berlin, Germany, including supplements (also available via the Beilstein online database)).

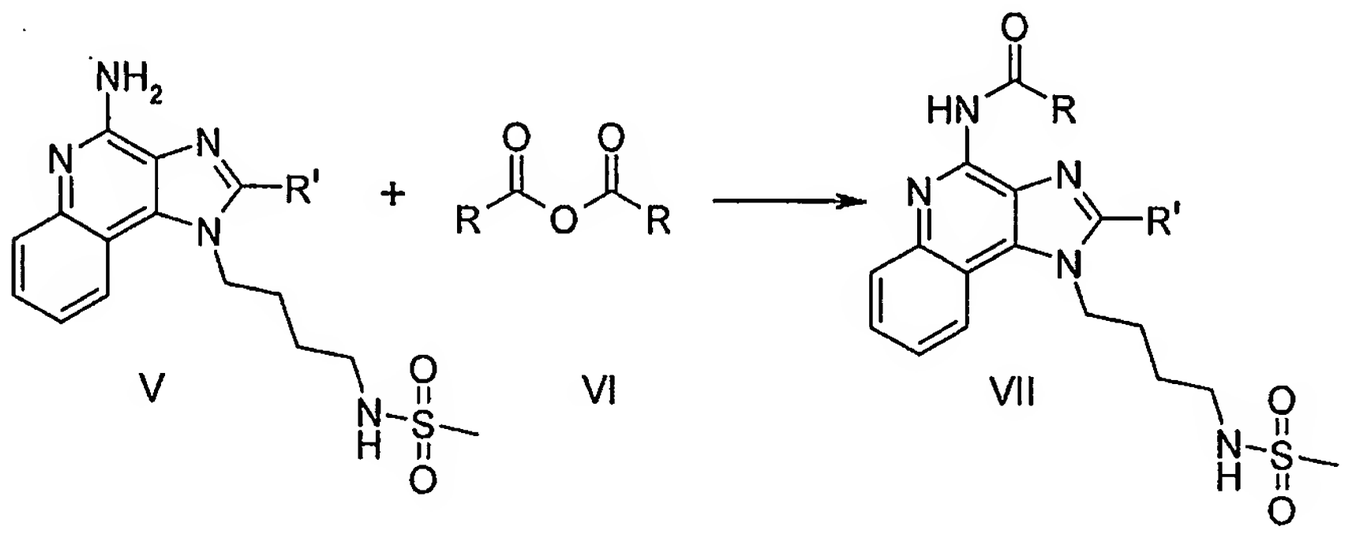
For illustrative purposes, the reaction schemes depicted below provide potential routes for synthesizing the compounds of the present invention. For more detailed description of the individual reaction steps, see the EXAMPLES section below. Those skilled in the art will appreciate that other synthetic routes may be used to synthesize the compounds of the invention.

Conventional methods and techniques of separation and purification can be used to isolate compounds of the invention, as well as various, pharmaceutically acceptable salts thereof. Such techniques may include, for example, all types of chromatography (high performance liquid chromatography (HPLC), column chromatography using common absorbents such as silica gel, and thin layer chromatography), recrystallization, and differential (i.e., liquid-liquid) extraction techniques.

Compounds of the invention can be prepared according to Reaction Scheme I wherein R and R' are as defined above. In Reaction Scheme I a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V is reacted with an acid anhydride of Formula VI to provide a *N*-(1*H*-imidazo[4,5-*c*]quinolin-4-yl)amide of Formula VII which is a subgenus of Formulas I, II, III, and IV. The reaction is carried out by combining a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V with an acid anhydride of Formula VI in a suitable solvent such as *N*-methyl-2-pyrrolidinone. The reaction can be carried out at ambient

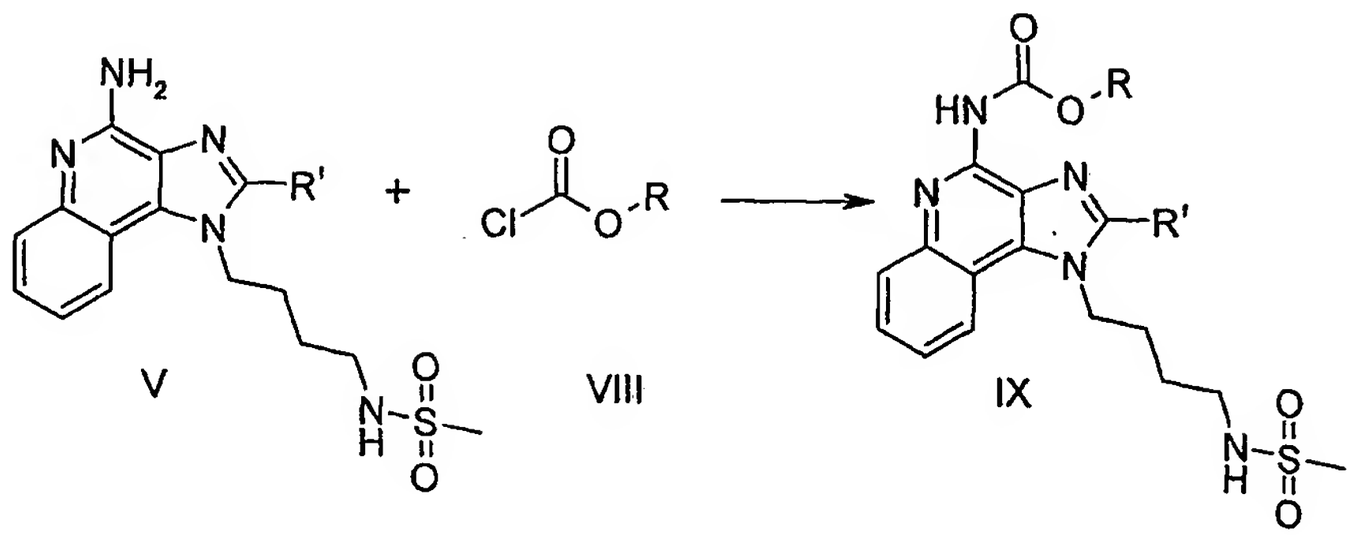
temperature and the product or a pharmaceutically acceptable salt thereof can be isolated using conventional methods. 1*H*-imidazo[4,5-*c*]quinolin-4-amines of Formula V are known and can be prepared using known synthetic methods, see U.S. 6,677,349 and the documents cited therein.

Reaction Scheme I



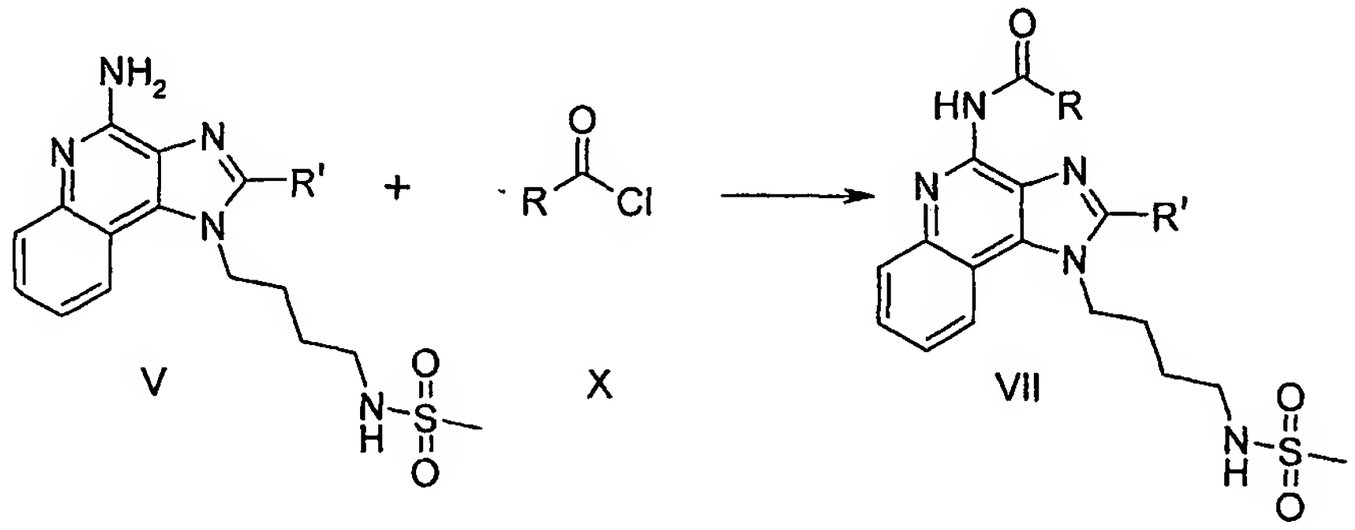
Compounds of the invention can be prepared according to Reaction Scheme II wherein R and R' are as defined above. In Reaction Scheme II a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V is reacted with a chloroformate of Formula VIII to provide a 1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate of Formula IX which is a subgenus of Formulas I, II, III, and IV. The reaction is carried out by adding a chloroformate of Formula VIII in a controlled fashion to a suspension or solution of a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V in a suitable solvent such as *N,N*-dimethylformamide or *N*-methyl-2-pyrrolidinone in the presence of a base such as triethylamine. The addition can be carried out at a sub-ambient temperature, such as for example 0 °C. The product or a pharmaceutically acceptable salt thereof can be isolated using conventional methods.

Reaction Scheme II



Compounds of the invention can be prepared according to Reaction Scheme III wherein R and R' are as defined above. In Reaction Scheme III a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V is reacted with an acid chloride of Formula X to provide a *N*-(1*H*-imidazo[4,5-*c*]quinolin-4-yl)amide of Formula VII which is a subgenus of Formulas I, II, III, and IV. The reaction is carried out by combining a 1*H*-imidazo[4,5-*c*]quinolin-4-amine of Formula V with an acid chloride of Formula VI in a suitable solvent such as dichloromethane, *N,N*-dimethylformamide or *N*-methyl-2-pyrrolidinone in the presence of a base such as triethylamine. The reaction can be carried out at ambient temperature and the product or a pharmaceutically acceptable salt thereof can be isolated using conventional methods.

Reaction Scheme III



Pharmaceutical Compositions and Biological Activity

Pharmaceutical compositions of the invention contain a therapeutically effective amount of a compound or salt described above in combination with a pharmaceutically acceptable carrier.

The terms "a therapeutically effective amount" and "effective amount" mean an amount of the compound or salt sufficient to induce a therapeutic or prophylactic effect, such as cytokine induction, immunomodulation, antitumor activity, and/or antiviral activity. The exact amount of compound or salt used in a pharmaceutical composition of the invention will vary according to factors known to those of skill in the art, such as the physical and chemical nature of the compound or salt, the nature of the carrier, and the intended dosing regimen.

In some embodiments, the compositions of the invention will contain sufficient active ingredient or prodrug to provide a dose of about 100 nanograms per kilogram (ng/kg) to about 50 milligrams per kilogram (mg/kg), preferably about 10 micrograms per kilogram (μg/kg) to about 5 mg/kg, of the compound or salt to the subject.

In other embodiments, the compositions of the invention will contain sufficient active ingredient or prodrug to provide a dose of, for example, from about 0.01 mg/m^2 to about 5.0 mg/m^2, computed according to the Dubois method, in which the body surface area of a subject (m^2) is computed using the subject's body weight: $m^2 = (wt\ kg^{0.425} \times height\ cm^{0.725}) \times 0.007184$, although in some embodiments the methods may be performed by administering a compound or salt or composition in a dose outside this range. In some of these embodiments, the method includes administering sufficient compound to provide a dose of from about 0.1 mg/m^2 to about 2.0 mg/m^2 to the subject, for example, a dose of from about 0.4 mg/m^2 to about 1.2 mg/m^2.

A variety of dosage forms may be used, such as tablets, lozenges, capsules, parenteral formulations, syrups, creams, ointments, aerosol formulations, transdermal patches, transmucosal patches and the like. These dosage forms can be prepared with conventional pharmaceutically acceptable carriers and additives using conventional methods, which generally include the step of bringing the active ingredient into association with the carrier.

The compounds or salts of the invention can be administered as the single therapeutic agent in the treatment regimen, or the compounds or salts described herein may be administered in combination with one another or with other active agents, including additional immune response modifiers, antivirals, antibiotics, antibodies, proteins, peptides, oligonucleotides, etc.

Compounds or salts of the invention have been shown to induce the production of certain cytokines in experiments performed according to the tests set forth below. These results indicate that the compounds or salts are useful for modulating the immune response in a number of different ways, rendering them useful in the treatment of a variety of disorders.

Cytokines whose production may be induced by the administration of compounds or salts of the invention generally include interferon-α (IFN-α) and tumor necrosis factor-α (TNF-α) as well as certain interleukins (IL). Cytokines whose biosynthesis may be induced by compounds or salts of the invention include IFN-α, TNF-α, IL-1, IL-6, IL-10 and IL-12, and a variety of other cytokines. Among other effects, these and other cytokines can inhibit virus production and tumor cell growth, making the compounds or salts useful in the treatment of viral diseases and neoplastic diseases. Accordingly, the invention provides a method of inducing cytokine biosynthesis in an animal comprising administering an effective amount of a compound or salt of the invention to the animal. The animal to which the compound or salt is administered for induction of cytokine biosynthesis may have a disease as described *infra*, for example a viral disease or a neoplastic disease, and administration of the compound or salt may provide therapeutic treatment. Alternatively, the compound or salt may be administered to the animal prior to the animal acquiring the disease so that administration of the compound or salt may provide a prophylactic treatment.

In addition to the ability to induce the production of cytokines, compounds or salts described herein can affect other aspects of the innate immune response. For example, natural killer cell activity may be stimulated, an effect that may be due to cytokine induction. The compounds or salts may also activate macrophages, which in turn stimulate secretion of nitric oxide and the production of additional cytokines. Further, the compounds or salts may cause proliferation and differentiation of B-lymphocytes.

Compounds or salts described herein can also have an effect on the acquired immune response. For example, the production of the T helper type 1 (T_H1) cytokine IFN-γ may be induced indirectly and the production of the T helper type 2 (T_H2) cytokines IL-4, IL-5 and IL-13 may be inhibited upon administration of the compounds or salts.

Whether for prophylaxis or therapeutic treatment of a disease, and whether for effecting innate or acquired immunity, the compound or salt or composition may be

administered alone or in combination with one or more active components as in, for example, a vaccine adjuvant. When administered with other components, the compound or salt or composition and other component or components may be administered separately; together but independently such as in a solution; or together and associated with one another such as (a) covalently linked or (b) non-covalently associated, e.g., in a colloidal suspension.

Conditions for which compounds or salts or compositions identified herein may be used as treatments include, but are not limited to:

(a) viral diseases such as, for example, diseases resulting from infection by an adenovirus, a herpesvirus (e.g., HSV-I, HSV-II, CMV, or VZV), a poxvirus (e.g., an orthopoxvirus such as variola or vaccinia, or molluscum contagiosum), a picornavirus (e.g., rhinovirus or enterovirus), an orthomyxovirus (e.g., influenzavirus), a paramyxovirus (e.g., parainfluenzavirus, mumps virus, measles virus, and respiratory syncytial virus (RSV)), a coronavirus (e.g., SARS), a papovavirus (e.g., papillomaviruses, such as those that cause genital warts, common warts, or plantar warts), a hepadnavirus (e.g., hepatitis B virus), a flavivirus (e.g., hepatitis C virus or Dengue virus), or a retrovirus (e.g., a lentivirus such as HIV);

(b) bacterial diseases such as, for example, diseases resulting from infection by bacteria of, for example, the genus Escherichia, Enterobacter, Salmonella, Staphylococcus, Shigella, Listeria, Aerobacter, Helicobacter, Klebsiella, Proteus, Pseudomonas, Streptococcus, Chlamydia, Mycoplasma, Pneumococcus, Neisseria, Clostridium, Bacillus, Corynebacterium, Mycobacterium, Campylobacter, Vibrio, Serratia, Providencia, Chromobacterium, Brucella, Yersinia, Haemophilus, or Bordetella;

(c) other infectious diseases, such as chlamydia, fungal diseases including but not limited to candidiasis, aspergillosis, histoplasmosis, cryptococcal meningitis, or parasitic diseases including but not limited to malaria, pneumocystis carnii pneumonia, leishmaniasis, cryptosporidiosis, toxoplasmosis, and trypanosome infection;

(d) neoplastic diseases, such as intraepithelial neoplasias, cervical dysplasia, actinic keratosis, basal cell carcinoma, squamous cell carcinoma, renal cell carcinoma, Kaposi's sarcoma, melanoma, leukemias including but not limited to acute myeloid leukemia, acute lymphocytic leukemia, chronic myeloid leukemia, chronic lymphocytic

leukemia, multiple myeloma, Hodgkin's lymphoma, non-Hodgkin's lymphoma, cutaneous T-cell lymphoma, B-cell lymphoma, and hairy cell leukemia, and other cancers;

(e) T_H2-mediated, atopic diseases, such as atopic dermatitis or eczema, eosinophilia, asthma, allergy, allergic rhinitis, and Ommen's syndrome;

(f) certain autoimmune diseases such as systemic lupus erythematosus, essential thrombocythaemia, multiple sclerosis, discoid lupus, alopecia areata; and

(g) diseases associated with wound repair such as, for example, inhibition of keloid formation and other types of scarring (e.g., enhancing wound healing, including chronic wounds).

Additionally, a compound or salt identified herein may be useful as a vaccine adjuvant for use in conjunction with any material that raises either humoral and/or cell mediated immune response, such as, for example, live viral, bacterial, or parasitic immunogens; inactivated viral, tumor-derived, protozoal, organism-derived, fungal, or bacterial immunogens; toxoids; toxins; self-antigens; polysaccharides; proteins; glycoproteins; peptides; cellular vaccines; DNA vaccines; autologous vaccines; recombinant proteins; and the like, for use in connection with, for example, BCG, cholera, plague, typhoid, hepatitis A, hepatitis B, hepatitis C, influenza A, influenza B, parainfluenza, polio, rabies, measles, mumps, rubella, yellow fever, tetanus, diphtheria, hemophilus influenza b, tuberculosis, meningococcal and pneumococcal vaccines, adenovirus, HIV, chicken pox, cytomegalovirus, dengue, feline leukemia, fowl plague, HSV-1 and HSV-2, hog cholera, Japanese encephalitis, respiratory syncytial virus, rotavirus, papilloma virus, yellow fever, and Alzheimer's Disease.

Compounds or salts identified herein may be particularly helpful in individuals having compromised immune function. For example, compounds or salts may be used for treating the opportunistic infections and tumors that occur after suppression of cell mediated immunity in, for example, transplant patients, cancer patients and HIV patients.

Thus, one or more of the above diseases or types of diseases, for example, a viral disease or a neoplastic disease may be treated in an animal in need thereof (having the disease) by administering a therapeutically effective amount of a compound or salt of the invention to the animal.

An animal may also be vaccinated by administering an effective amount of a compound or salt described herein, as a vaccine adjuvant. In one embodiment, there is

provided a method of vaccinating an animal comprising administering an effective amount of a compound or salt described herein to the animal as a vaccine adjuvant.

An amount of a compound or salt effective to induce cytokine biosynthesis is an amount sufficient to cause one or more cell types, such as monocytes, macrophages, dendritic cells and B-cells to produce an amount of one or more cytokines such as, for example, IFN-α, TNF-α, IL-1, IL-6, IL-10 and IL-12 that is increased (induced) over a background level of such cytokines. The precise amount will vary according to factors known in the art but is expected to be a dose of about 100 ng/kg to about 50 mg/kg, preferably about 10 μg/kg to about 5 mg/kg. In other embodiments, the amount is expected to be a dose of, for example, from about 0.01 mg/m^2 to about 5.0 mg/m^2, (computed according to the Dubois method as described above) although in some embodiments the induction or inhibition of cytokine biosynthesis may be performed by administering a compound or salt in a dose outside this range. In some of these embodiments, the method includes administering sufficient compound or salt or composition to provide a dose of from about 0.1 mg/m^2 to about 2.0 mg/m^2 to the subject, for example, a dose of from about 0.4 mg/m^2 to about 1.2 mg/m^2.

The invention also provides a method of treating a viral infection in an animal and a method of treating a neoplastic disease in an animal comprising administering an effective amount of a compound or salt of the invention to the animal. An amount effective to treat or inhibit a viral infection is an amount that will cause a reduction in one or more of the manifestations of viral infection, such as viral lesions, viral load, rate of virus production, and mortality as compared to untreated control animals. The precise amount that is effective for such treatment will vary according to factors known in the art but is expected to be a dose of about 100 ng/kg to about 50 mg/kg, preferably about 10 μg/kg to about 5 mg/kg. An amount of a compound or salt effective to treat a neoplastic condition is an amount that will cause a reduction in tumor size or in the number of tumor foci. Again, the precise amount will vary according to factors known in the art but is expected to be a dose of about 100 ng/kg to about 50 mg/kg, preferably about 10 μg/kg to about 5 mg/kg. In other embodiments, the amount is expected to be a dose of, for example, from about 0.01 mg/m^2 to about 5.0 mg/m^2, (computed according to the Dubois method as described above) although in some embodiments either of these methods may be performed by administering a compound or salt in a dose outside this range. In some of

these embodiments, the method includes administering sufficient compound or salt to provide a dose of from about 0.1 mg/m^2 to about 2.0 mg/m^2 to the subject, for example, a dose of from about 0.4 mg/m^2 to about 1.2 mg/m^2.

Thus, one or more of the above diseases or types of diseases, for example, a viral disease or a neoplastic disease may be treated in an animal in need thereof (having the disease) by administering a therapeutically effective amount of a compound or salt of Formula I, II, III, IV, any of the embodiments described herein, or a combination thereof to the animal. An animal may also be vaccinated by administering an effecive amount of a compound or salt of Formula I, II, III, IV, any of the embodiments described herein, or a combination thereof to the animal as a vaccine adjuvant. In one embodiment, there is provided a method of vaccinating an animal comprising administering an effective amount of a compound or salt described herein to the animal as a vaccine adjuvant.

The methods of the invention may be performed on any suitable subject. Suitable subjects include but are not limited to animals such as but not limited to humans, non-human primates, rodents, dogs, cats, horses, pigs, sheep, goats, or cows.

In addition to the formulations and uses described specifically herein, other formulations, uses, and administration devices suitable for compounds of the present invention are described in, for example, International Publication Nos. WO 03/077944 and WO 02/036592, U.S. Patent No. 6,245,776, and U.S. Publication Nos. 2003/0139364, 2003/185835, 2004/0258698, 2004/0265351, 2004/076633, and 2005/0009858.

Objects and advantages of this invention are further illustrated by the following examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this invention.

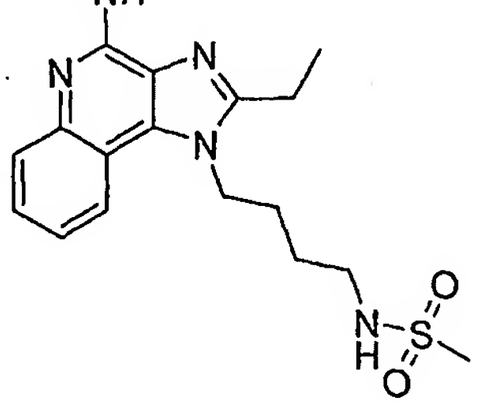
EXAMPLES

In the examples below automated flash chromatography was carried out using a COMBIFLASH system (an automated high-performance flash purification product available from Teledyne Isco, Inc., Lincoln, Nebraska, USA) or a HORIZON HPFC system (an automated high-performance flash purification product available from Biotage, Inc, Charlottesville, Virginia, USA). The eluent used for each purification is given in the

example. In some chromatographic separations, the solvent mixture 80/18/2 v/v/v chloroform/methanol/concentrated ammonium hydroxide (CMA) was used as the polar component of the eluent. In these separations, CMA was mixed with chloroform in the indicated ratio.

Example 1

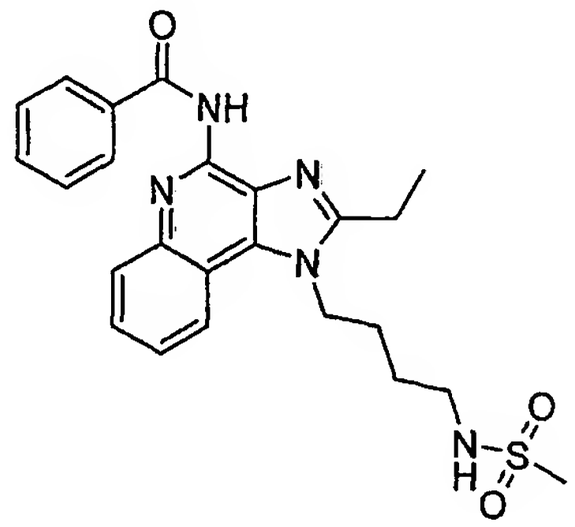
N-(2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)acetamide



Acetic anhydride (10 mL) and *N*-methyl-2-pyrrolidinone (NMP) (50 mL) were added sequentially to *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (0.5 g) and the reaction mixture was stirred for 1 hour. The reaction mixture was diluted with ethyl acetate (about 550 mL) and then washed with water (1 L total in portions of 100 – 150 mL). The organic layer was separated, dried over magnesium sulfate, filtered, and then concentrated under reduced pressure. The residue was purified by automated flash chromatography (silica gel eluting with a gradient of 0 – 10% methanol in dichloromethane containing 1% ammonium hydroxide) to provide about 100 mg of an oil. The oil was dissolved in acetonitrile. Diethyl ether was added to the solution and it was concentrated under reduced pressure to provide 100 mg of *N*-(2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)acetamide as a white solid, mp 90-91 °C. Anal calcd for $C_{19}H_{25}N_5O_3S$: C, 56.55; H, 6.24; N, 17.36. Found: C, 56.12; H, 5.95; N, 16.98.

Example 2

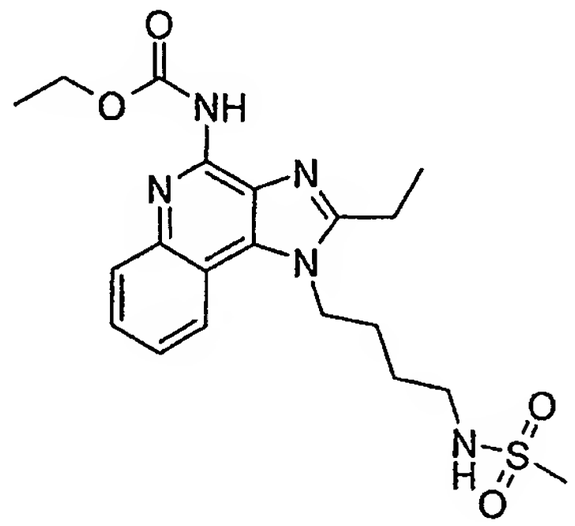
N-(2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)benzamide



NMP (5 mL) and benzoic anhydride (0.63 g, 1 equivalent (eq)) were added sequentially to *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1 g, 1 eq) and the reaction mixture was stirred at ambient temperature. After 4 hours additional NMP (about 1 mL) was added. After 5 hours additional benzoic anhydride (0.63 g) was added and the reaction mixture was stirred overnight. The reaction mixture was diluted with diethyl ether (about 50 mL). A white solid was isolated by filtration, rinsed with diethyl ether, and then dried under vacuum to provide about 1 g of a white solid. This material was purified by automated flash chromatography (silica gel eluting with a gradient of 0 – 10% methanol in dichloromethane containing 1% ammonium hydroxide) to provide 507 mg of *N*-(2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)benzamide as a white powder, mp 249-250 °C. Anal calcd for $C_{24}H_{27}N_5O_3S \cdot 0.10\ H_2O$: C, 61.68; H, 5.87; N, 14.98. Found: C, 61.42; H, 5.80; N, 14.96.

Example 3

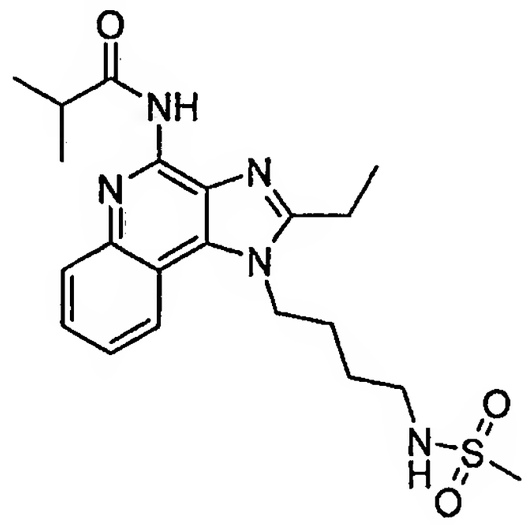
Ethyl 2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate



Triethylamine (3.86 mL, 10 eq) was added to a chilled (ice/water bath) suspension of *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1.0 g, 1 eq) in *N,N*-dimethylformamide (DMF) (10 mL). Ethyl chloroformate (1.5 g, 5 eq) was added dropwise to give a clear solution. The reaction mixture was allowed to come to ambient temperature with stirring for 2 hours. Additional triethylamine (3.86 mL, 10 eq) and ethyl chloroformate (3.86 mL, 10 eq) were added and the reaction mixture was stirred overnight. The reaction mixture was poured onto crushed ice and then extracted with dichloromethane (50 mL). The organic layer was washed sequentially with water (2 x 50 mL), 4% sodium carbonate (50 mL), water (50 mL), and brine (50 mL) and then concentrated under reduced pressure. The residue was purified by automated flash chromatography (silica gel eluted with a linear gradient of 0 – 25% CMA in chloroform, 2500 mL) followed by recrystallization from acetonitrile to provide 0.815 g of ethyl 2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate as a white crystalline solid, mp 185-187 °C. Anal calcd for $C_{20}H_{27}N_5O_4S$: C, 55.41; H, 6.28; N, 16.15. Found: C, 55.30; H, 6.29; N, 16.24.

Example 4

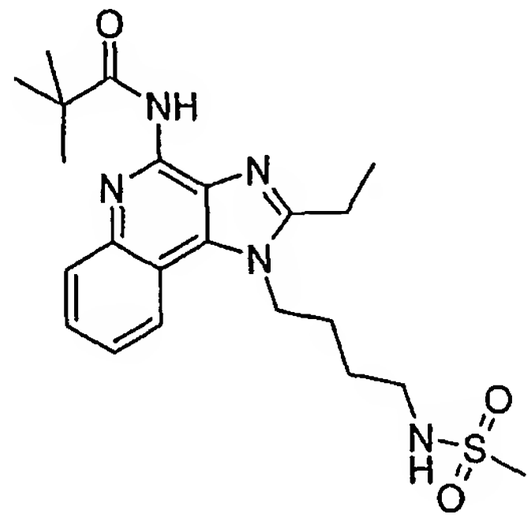
N-(2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)-2-methylpropanamide



NMP (3 mL) and isobutyric anhydride (459 µL, 1 eq) were added sequentially to *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1 g, 1 eq) and the reaction mixture was stirred at ambient temperature. After 4 hours additional isobutyric anhydride (about 0.5 eq) was added and the reaction mixture was stirred overnight. The reaction mixture was diluted with diethyl ether (about 25 mL) and stirred for 15 minutes. The solvent was decanted from the resulting white precipitate. The solid was dried under vacuum and then purified by automated flash chromatography (silica gel eluting with a gradient of 0 – 10% methanol in dichloromethane containing 1% ammonium hydroxide) to provide 1.1 g of *N*-(2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)-2-methylpropanamide as a white powder, mp 122-124 °C. Anal calcd for $C_{21}H_{29}N_5O_3S$: C, 58.45; H, 6.77; N, 16.23. Found: C, 57.69; H, 6.82; N, 16.06.

Example 5

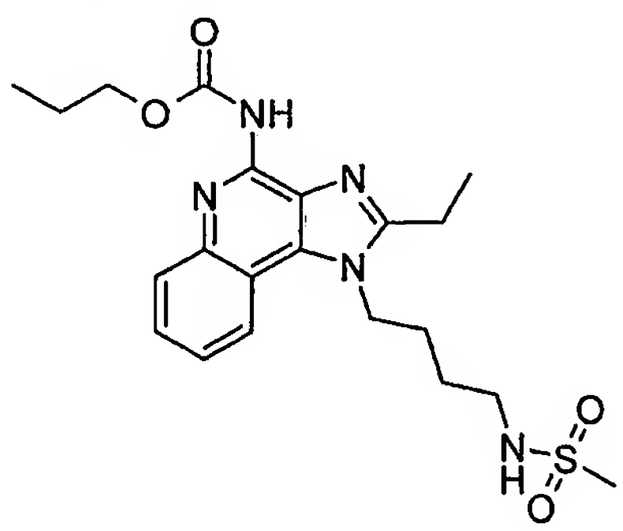
N-(2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)-2,2-dimethylpropanamide



NMP (3 mL) and trimethylacetic anhydride (564 µL, 1 eq) were added sequentially to *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1 g, 1 eq) and the reaction mixture was stirred at ambient temperature. After 4 hours additional trimethylacetic anhydride (about 0.5 eq) was added and the reaction mixture was stirred overnight. The reaction mixture was diluted with diethyl ether (about 25 mL) and stirred for 15 minutes. The solvent was decanted from the resulting white precipitate. The solid was dried under vacuum and then purified by automated flash chromatography (silica gel eluting with a gradient of 0 – 10% methanol in dichloromethane containing 1% ammonium hydroxide) to provide 0.822 g of *N*-(2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-yl)-2,2-dimethylpropanamide as a white powder, mp 220-221 °C. Anal calcd for $C_{22}H_{31}N_5O_3S$: C, 59.30; H, 7.01; N, 15.72. Found: C, 59.44; H, 6.90; N, 15.87.

Example 6

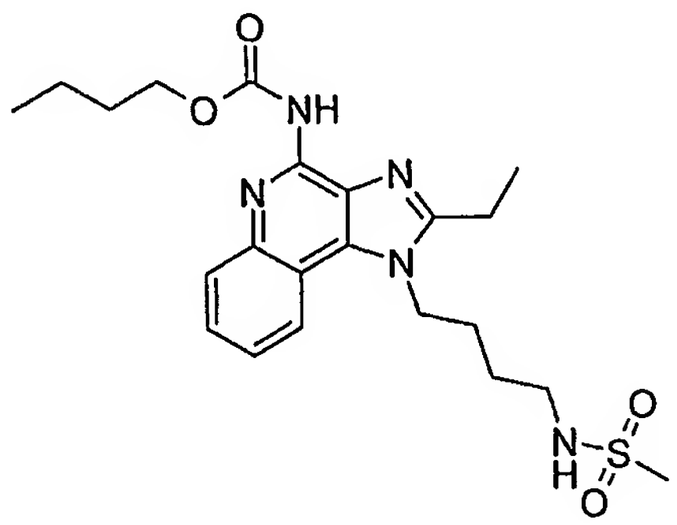
Propyl 2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate



Triethylamine (1.93 mL, 5 eq) was added to a chilled (ice/water bath) suspension of *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1.0 g, 1 eq) in NMP (6.0 mL). Propyl chloroformate (1.02 g, 3 eq) was added dropwise. The reaction mixture was allowed to come to ambient temperature and stirred for 24 hours. The reaction mixture was diluted with cold water (25 mL) and then extracted with dichloromethane (50 mL). The organic layer was washed sequentially with water (2 x 50 mL), 4% sodium carbonate (50 mL), water (50 mL), and brine (50 mL) and then concentrated under reduced pressure. The residue was purified by automated flash chromatography (silica gel eluted with a linear gradient of 0 – 25% CMA in chloroform, 2000 mL) followed by recrystallization from acetonitrile to provide 0.427 g of propyl 2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate as a white solid, mp 155-157 °C. Anal calcd for $C_{21}H_{29}N_5O_4S$: C, 56.36; H, 6.53; N, 15.65. Found: C, 56.37; H, 6.37; N, 15.70.

Example 7

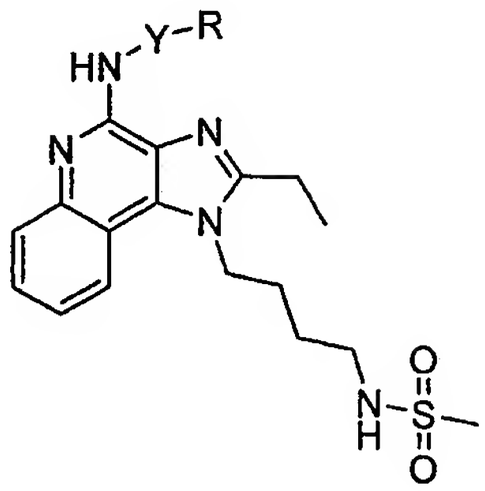
Butyl 2-Ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate



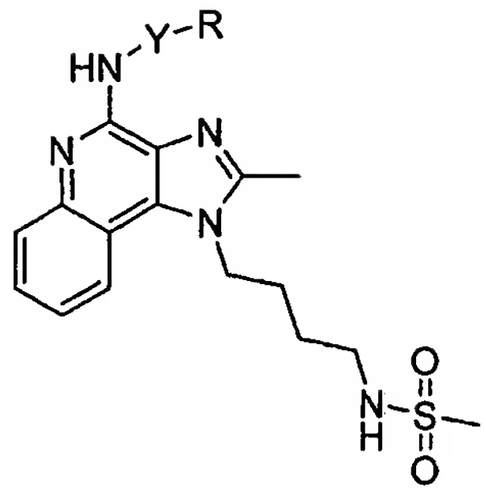
Triethylamine (1.93 mL, 5 eq) was added to a chilled (ice/water bath) suspension of *N*-[4-(4-amino-2-ethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl)butyl]methanesulfonamide (1.0 g, 1 eq) in NMP (6.0 mL). *n*-Butyl chloroformate (1.13 g, 3 eq) was added dropwise. The reaction mixture was allowed to come to ambient temperature and stirred for 24 hours. The reaction mixture was diluted with cold water (25 mL) and then extracted with dichloromethane (50 mL). The organic layer was washed sequentially with water (2 x 50 mL), 4% sodium carbonate (50 mL), water (50 mL), and brine (50 mL) and then concentrated under reduced pressure. The residue was purified by automated flash chromatography (silica gel eluted with a linear gradient of 0 – 25% CMA in chloroform, 2000 mL) followed by recrystallization from acetonitrile to provide 0.35 g of butyl 2-ethyl-1-{4-[(methylsulfonyl)amino]butyl}-1*H*-imidazo[4,5-*c*]quinolin-4-ylcarbamate as a white solid, mp 164-166 °C. Anal calcd for $C_{22}H_{31}N_5O_4S$: C, 57.25; H, 6.77; N, 15.17. Found: C, 57.13; H, 6.61; N, 15.20.

Exemplary Compounds

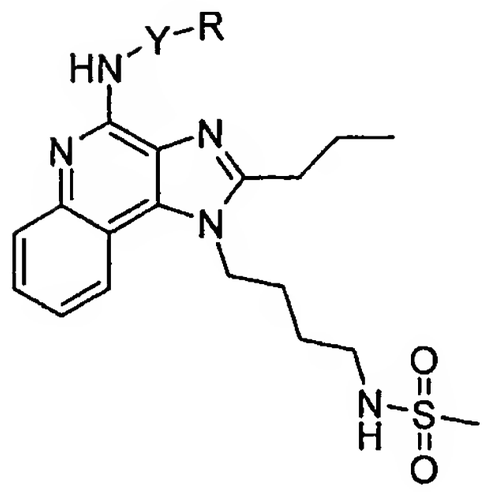
Certain exemplary compounds, including some of those described above in the Examples, have one of the following Formulas (IIa, IIIa, or IVa) and a -Y-R substituent shown in the following table, wherein each line of the table is matched with a Formula (IIa, IIIa, or IVa) to represent a specific embodiment of the invention.



IIa



IIIa



IVa

-Y-R
-C(O)-CH_3
-C(O)-CH_2CH_3
-C(O)-$CH_2CH_2CH_3$
-C(O)-$CH_2(CH_3)_2$
-C(O)-$CH_2CH_2CH_2CH_3$
-C(O)-$CH_2CH_2(CH_3)_2$
-C(O)-$C(CH_3)_3$
-C(O)-phenyl
-C(O)-CH_2-phenyl
-C(O)-O-CH_3
-C(O)-O-CH_2CH_3
-C(O)-O-$CH_2CH_2CH_3$
-C(O)-O-$CH_2(CH_3)_2$
-C(O)-O-$CH_2CH_2CH_2CH_3$
-C(O)-O-$CH_2CH_2(CH_3)_2$
-C(O)-O-$C(CH_3)_3$
-C(O)-O-phenyl
-C(O)-O-CH_2-phenyl

Compounds of the invention have been found to bring about modulation of cytokine biosynthesis as shown by increased levels of interferon α and/or tumor necrosis factor α in human cells when tested using the method described below.

CYTOKINE INDUCTION IN HUMAN CELLS

An in vitro human blood cell system is used to assess cytokine induction. Activity is based on the measurement of interferon (α) and tumor necrosis factor (α) (IFN-α and TNF-α, respectively) secreted into culture media as described by Testerman *et al.* in "Cytokine Induction by the Immunomodulators Imiquimod and S-27609", *Journal of Leukocyte Biology*, *58*, 365-372 (September, 1995).

Blood Cell Preparation for Culture

Whole blood from healthy human donors is collected by venipuncture into vacutainer tubes or syringes containing EDTA. Peripheral blood mononuclear cells (PBMC) are separated from whole blood by density gradient centrifugation using HISTOPAQUE-1077 (Sigma, St. Louis, MO) or Ficoll-Paque Plus (Amersham Biosciences Piscataway, NJ). Blood is diluted 1:1 with Dulbecco's Phosphate Buffered Saline (DPBS) or Hank's Balanced Salts Solution (HBSS). Alternately, whole blood is placed in Accuspin (Sigma) or LeucoSep (Greiner Bio-One, Inc., Longwood, FL) centrifuge frit tubes containing density gradient medium. The PBMC layer is collected and washed twice with DPBS or HBSS and re-suspended at 4 x 10^6 cells/mL in RPMI complete. The PBMC suspension is added to 96 well flat bottom sterile tissue culture plates containing an equal volume of RPMI complete media containing test compound.

Compound Preparation

The compounds are solubilized in dimethyl sulfoxide (DMSO). The DMSO concentration should not exceed a final concentration of 1% for addition to the culture wells. The compounds are generally tested at concentrations ranging from 30-0.014 μM. Controls include cell samples with media only, cell samples with DMSO only (no compound), and cell samples with reference compound.

Incubation

The solution of test compound is added at 60 μM to the first well containing RPMI complete and serial 3 fold dilutions are made in the wells. The PBMC suspension is then added to the wells in an equal volume, bringing the test compound concentrations to the

desired range (usually 30-0.014 μM). The final concentration of PBMC suspension is 2 x 10^6 cells/mL. The plates are covered with sterile plastic lids, mixed gently and then incubated for 18 to 24 hours at 37°C in a 5% carbon dioxide atmosphere.

Separation

Following incubation the plates are centrifuged for 10 minutes at 1000 rpm (approximately 200 x g) at 4°C. The cell-free culture supernatant is removed and transferred to sterile polypropylene tubes. Samples are maintained at -30 to -70°C until analysis. The samples are analyzed for IFN-α by ELISA and for TNF-α by IGEN/BioVeris Assay.

Interferon (α) and Tumor Necrosis Factor (α) Analysis

IFN-α concentration is determined with a human multi-subtype colorimetric sandwich ELISA (Catalog Number 41105) from PBL Biomedical Laboratories, Piscataway, NJ. Results are expressed in pg/mL.

The TNF-α concentration is determined by ORIGEN M-Series Immunoassay and read on an IGEN M-8 analyzer from BioVeris Corporation, formerly known as IGEN International, Gaithersburg, MD. The immunoassay uses a human TNF-α capture and detection antibody pair (Catalog Numbers AHC3419 and AHC3712) from Biosource International, Camarillo, CA. Results are expressed in pg/mL.

Assay Data and Analysis

In total, the data output of the assay consists of concentration values of TNF-α and IFN-α (y-axis) as a function of compound concentration (x-axis).

Analysis of the data has two steps. First, the greater of the mean DMSO (DMSO control wells) or the experimental background (usually 20 pg/mL for IFN-α and 40 pg/mL for TNF-α) is subtracted from each reading. If any negative values result from background subtraction, the reading is reported as " * ", and is noted as not reliably detectable. In subsequent calculations and statistics, " * ", is treated as a zero. Second, all background subtracted values are multiplied by a single adjustment ratio to decrease experiment to experiment variability. The adjustment ratio is the area of the reference compound in the new experiment divided by the expected area of the reference compound

based on the past 61 experiments (unadjusted readings). This results in the scaling of the reading (y-axis) for the new data without changing the shape of the dose-response curve. The reference compound used is 2-[4-amino-2-ethoxymethyl-6,7,8,9-tetrahydro-α,α-dimethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl]ethanol hydrate (U.S. Patent No. 5,352,784; Example 91) and the expected area is the sum of the median dose values from the past 61 experiments.

The minimum effective concentration is calculated based on the background-subtracted, reference-adjusted results for a given experiment and compound. The minimum effective concentration (μmolar) is the lowest of the tested compound concentrations that induces a response over a fixed cytokine concentration for the tested cytokine (usually 20 pg/mL for IFN-α and 40 pg/mL for TNF-α). The maximal response is the maximal amount of cytokine (pg/ml) produced in the dose-response.

CYTOKINE INDUCTION IN HUMAN CELLS

(High Throughput Screen)

The CYTOKINE INDUCTION IN HUMAN CELLS test method described above was modified as follows for high throughput screening.

Blood Cell Preparation for Culture

Whole blood from healthy human donors is collected by venipuncture into vacutainer tubes or syringes containing EDTA. Peripheral blood mononuclear cells (PBMC) are separated from whole blood by density gradient centrifugation using HISTOPAQUE-1077 (Sigma, St. Louis, MO) or Ficoll-Paque Plus (Amersham Biosciences Piscataway, NJ). Whole blood is placed in Accuspin (Sigma) or LeucoSep (Greiner Bio-One, Inc., Longwood, FL) centrifuge frit tubes containing density gradient medium. The PBMC layer is collected and washed twice with DPBS or HBSS and re-suspended at 4 x 10^6 cells/mL in RPMI complete (2-fold the final cell density). The PBMC suspension is added to 96-well flat bottom sterile tissue culture plates.

Compound Preparation

The compounds are solubilized in dimethyl sulfoxide (DMSO). The compounds are generally tested at concentrations ranging from 30 - 0.014 μM. Controls include cell

samples with media only, cell samples with DMSO only (no compound), and cell samples with a reference compound 2-[4-amino-2-ethoxymethyl-6,7,8,9-tetrahydro-α,α-dimethyl-1H-imidazo[4,5-c]quinolin-1-yl]ethanol hydrate (U.S. Patent No. 5,352,784; Example 91) on each plate. The solution of test compound is added at 7.5 mM to the first well of a dosing plate and serial 3 fold dilutions are made for the 7 subsequent concentrations in DMSO. RPMI Complete media is then added to the test compound dilutions in order to reach a final compound concentration of 2-fold higher (60 - 0.028 μM) than the final tested concentration range.

Incubation

Compound solution is then added to the wells containing the PBMC suspension bringing the test compound concentrations to the desired range (usually 30 - 0.014 μM) and the DMSO concentration to 0.4 %. The final concentration of PBMC suspension is $2x10^6$ cells/mL. The plates are covered with sterile plastic lids, mixed gently and then incubated for 18 to 24 hours at 37°C in a 5% carbon dioxide atmosphere.

Separation

Following incubation the plates are centrifuged for 10 minutes at 1000 rpm (approximately 200 g) at 4°C. 4-plex Human Panel MSD MULTI-SPOT 96-well plates are pre-coated with the appropriate capture antibodies by MesoScale Discovery, Inc. (MSD, Gaithersburg, MD). The cell-free culture supernatants are removed and transferred to the MSD plates. Fresh samples are typically tested, although they may be maintained at -30 to -70°C until analysis.

Interferon-α and Tumor Necrosis Factor-α Analysis

MSD MULTI-SPOT plates contain within each well capture antibodies for human TNF-α and human IFN-α that have been pre-coated on specific spots. Each well contains four spots: one human TNF-α capture antibody (MSD) spot, one human IFN- α capture antibody (PBL Biomedical Laboratories, Piscataway, NJ) spot, and two inactive bovine serum albumin spots. The human TNF-α capture and detection antibody pair is from MesoScale Discovery. The human IFN-α multi-subtype antibody (PBL Biomedical Laboratories) captures all IFN-α subtypes except IFN-α F (IFNA21). Standards consist of

recombinant human TNF-α (R&D Systems, Minneapolis, MN) and IFN-α (PBL Biomedical Laboratories). Samples and separate standards are added at the time of analysis to each MSD plate. Two human IFN-α detection antibodies (Cat. Nos. 21112 & 21100, PBL) are used in a two to one ratio (weight:weight) to each other to determine the IFN-α concentrations. The cytokine-specific detection antibodies are labeled with the SULFO-TAG reagent (MSD). After adding the SULFO-TAG labeled detection antibodies to the wells, each well's electrochemoluminescent levels are read using MSD's SECTOR HTS READER. Results are expressed in pg/mL upon calculation with known cytokine standards.

Assay Data and Analysis

In total, the data output of the assay consists of concentration values of TNF-α or IFN-α (y-axis) as a function of compound concentration (x-axis).

A plate-wise scaling is performed within a given experiment aimed at reducing plate-to-plate variability associated within the same experiment. First, the greater of the median DMSO (DMSO control wells) or the experimental background (usually 20 pg/mL for IFN-α and 40 pg/mL for TNF-α) is subtracted from each reading. Negative values that may result from background subtraction are set to zero. Each plate within a given experiment has a reference compound that serves as a control. This control is used to calculate a median expected area under the curve across all plates in the assay. A plate-wise scaling factor is calculated for each plate as a ratio of the area of the reference compound on the particular plate to the median expected area for the entire experiment. The data from each plate are then multiplied by the plate-wise scaling factor for all plates. Only data from plates bearing a scaling factor of between 0.5 and 2.0 (for both cytokines IFN-α, TNF-α) are reported. Data from plates with scaling factors outside the above mentioned interval are retested until they bear scaling factors inside the above mentioned interval. The above method produces a scaling of the y-values without altering the shape of the curve. The reference compound used is 2-[4-amino-2-ethoxymethyl-6,7,8,9-tetrahydro-α,α-dimethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl]ethanol hydrate (U.S. Patent No. 5,352,784; Example 91). The median expected area is the median area across all plates that are part of a given experiment.

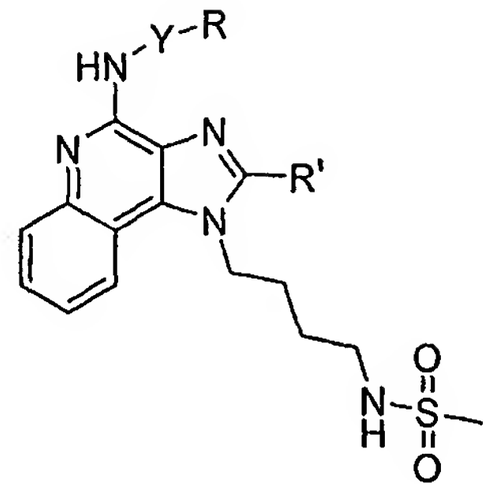
A second scaling may also be performed to reduce inter-experiment variability (across multiple experiments). All background-subtracted values are multiplied by a single adjustment ratio to decrease experiment-to-experiment variability. The adjustment ratio is the area of the reference compound in the new experiment divided by the expected area of the reference compound based on an average of previous experiments (unadjusted readings). This results in the scaling of the reading (y-axis) for the new data without changing the shape of the dose-response curve. The reference compound used is 2-[4-amino-2-ethoxymethyl-6,7,8,9-tetrahydro-α,α-dimethyl-1*H*-imidazo[4,5-*c*]quinolin-1-yl]ethanol hydrate (U.S. Patent No. 5,352,784; Example 91) and the expected area is the sum of the median dose values from an average of previous experiments.

The minimum effective concentration is calculated based on the background-subtracted, reference-adjusted results for a given experiment and compound. The minimum effective concentration (μmolar) is the lowest of the tested compound concentrations that induces a response over a fixed cytokine concentration for the tested cytokine (usually 20 pg/mL for IFN-α and 40 pg/mL for TNF-α). The maximal response is the maximal amount of cytokine (pg/ml) produced in the dose-response.

The complete disclosures of the patents, patent documents, and publications cited herein are incorporated by reference in their entirety as if each were individually incorporated. Various modifications and alterations to this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention. It should be understood that this invention is not intended to be unduly limited by the illustrative embodiments and examples set forth herein and that such examples and embodiments are presented by way of example only with the scope of the invention intended to be limited only by the claims set forth herein as follows.

WHAT IS CLAIMED IS:

1. A compound of the Formula I



I

wherein:

Y is selected from the group consisting of -C(O)- and -C(O)-O-;

R is selected from the group consisting of alkyl, aryl, arylalkylenyl, heteroaryl, heteroarylalkylenyl, heterocyclyl, and heterocyclylalkylenyl; wherein aryl and arylalkylenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of alkyl, alkoxy, aryl, and halogen; and wherein the atom in heterocyclyl attached to Y is a carbon atom; and

R' is selected from the group consisting of methyl, ethyl, and *n*-propyl;

or a pharmaceutically acceptable salt thereof.

2. The compound or salt of claim 1 wherein Y is -C(O)-.

3. The compound or salt of claim 1 wherein Y is -C(O)-O-.

4. The compound or salt of claim 1, 2, or 3 wherein R is alkyl, aryl, or arylalkylenyl.

5. The compound or salt of claim 4 wherein R is C_{1-10} alkyl.

6. The compound or salt of claim 5 wherein R is C_{1-5} alkyl.

7. The compound or salt of claim 6 wherein R is selected from the group consisting of methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, and *tert*-butyl.

8. The compound or salt of claim 4 wherein R is aryl.

9. The compound or salt of claim 8 wherein R is phenyl.

10. The compound or salt of claim 4 wherein R is arylalkylenyl.

11. The compound or salt of claim 10 wherein R is benzyl.

12. The compound or salt of any one of claims 1 through 11 wherein R' is ethyl.

13. The compound or salt of any one of claims 1 through 11 wherein R' is methyl.

14. The compound or salt of any one of claims 1 through 11 wherein R' is *n*-propyl.

15. A pharmaceutical composition comprising a therapeutically effective amount of a compound or salt of any one of claims 1 through 14 and a pharmaceutically acceptable carrier.

16. A method of inducing cytokine biosynthesis in an animal comprising administering an effective amount of a compound or salt of any one claims 1 through 14 or the pharmaceutical composition of claim 15 to the animal.

17. A method of treating a viral disease in an animal comprising administering a therapeutically effective amount of a compound or salt of any one of claims 1 through 14 or the pharmaceutical composition of claim 15 to the animal.

18. A method of treating a neoplastic disease in an animal comprising administering a therapeutically effective amount of a compound or salt of any one of claims 1 through 14 or the pharmaceutical composition of claim 15 to the animal.